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B.TECH. DEGREE EXAMINATION, NOVEMBER 2014

Third Semester

Branch : Applied Electronics and Instrumentation/ Electronics and Communication Engineering

AI 010 304 / EC 010 304 — SOLID STATE DEVICES (AI, EC)

(New Scheme—2010 Admission onwards)

[Regular/Improvement/Supplementary]

Time : Three Hours Maximum : 100 Marks

Part A

Answer **all** *questions briefly.*
Each question carries 3 marks.

1. Explain direct and indirect band-gap semiconductors with examples.
2. Explain diffusion and drift currents in semiconductor with the help of expressions.
3. Define delay time, rise time and fall time in switching diode.
4. Define injection efficiency and transport factor of a BJT. How they are related to α and β ?
5. Distinguish between Enhancement and Depletion mode MOSFETs.

(5 × 3 = 15 marks)

Part B

Answer **all** *questions.*
Each question carries 5 marks.

6. A silicon sample is doped with 5×10^{16} Arsenic atoms/cc and 3×10^{16} Boron atoms/cc. Determine (i) electron and hole concentrations at room temperature ; and (ii) position of Fermi level. Assume $n_i = 1.5 \times 10^{10}$/cc at room temperature.
7. Calculate the contact potential of a PN junction diode having $N_A = 2 \times 10^{16}$/cc and $N_D = 5 \times 10^{13}$/cc at T = 300° K. Take $n_i = 1.5 \times 10^{10}$/cc.
8. A silicon abrupt *pn* junction at 300 K has $N_A = 2 \times 10^{16}$/cc and $N_D = 5 \times 10^{13}$/cc. The area of cross-section is 10^{-5} cm.^{2} Calculate the junction capacitance. $\epsilon_0 = 8.854 \times 10^{-14}$, $\epsilon_r = 11.8$, $n_i = 1.5 \times 10^{10}$/cc.
9. What are the different modes of operations of a transistor ? Plot minority carrier distribution for PNP transistor in all modes.
10. Explain channel length modulation in MOSFET.

(5 × 5 = 25 marks)

Turn over

Part C

Answer **all** *questions.*
Each full question carries 12 *marks.*

11. Derive :

$$\text{(i) } n_o = n_i\, e^{\left(\frac{E_F - E_i}{KT}\right)}; \quad \text{(ii) } p_o = n_i\, e^{\left(\frac{E_i - E_F}{KT}\right)}.$$

(6 + 6 = 12 marks)

Or

12. Derive the continuity equations for holes and electrons in a semiconductor. State the assumptions made.

13. Sketch and explain formation of space charge region in a PN junction. Also plot charge density, electric field, barrier potential and energy band diagram under thermal equilibrium and explain.

Or

14. What is a P^+N diode ? Derive expression for its depletion, region width. If for an abrupt P^+N diode, $N_D = 6 \times 10^{14}$/cc, $V_{BR} = 500$ volt, $\epsilon_r = 12.4$, $\epsilon_0 = 8.854 \times 10^{-14}$, calculate the depletion region width.

15. With neat sketches, explain the working and characteristics of :

    (i) Zener diode.

    (ii) Schottky barrier diode.

    (iii) Photodiodes.

(3 × 4 = 12 marks)

Or

16. A 0.45 μm, thick sample of GaAs is illuminated with monochromatic light of $h\upsilon = 2$ eV. The absorption coefficient is 5×10^4/cm. The power incident on the sample is 10 mW.

    (i) Calculate the total energy absorbed by the sample per second (J/S).

    (ii) Find the rate of excess thermal energy given up by the electrons to the lattice before recombination (J/S).

    (iii) Find the number of photons per second given off from recombination events assuming perfect quantum efficiency.

(3 × 4 = 12 marks)

17. With necessary diagrams, explain :

    (i) Effect of base narrowing in BJT.

    (ii) Punch through effect.

    (iii) Emitter crowding.

(3 × 4 = 12 marks)

Or

18. With neat sketches, explain the shape of depletion region, with a cross-sectional view of JFET. Explain pinch-off, saturation and the effect of negative gate bias with the help of VI characteristics.

19. (a) With neat constructional diagram and energy band diagrams, explain MOS capacitor.

(b) Calculate the maximum width of the depletion region for an ideal MOS capacitor on *p*-type silicon with $N_A = 10^{16}$/CC, $n_i = 1.5 \times 10^{10}$/CC. $\epsilon_r = 11.8$, $\epsilon_0 = 8.854 \times 10^{-14}$.

(7 + 5 = 12 marks)

Or

20. With neat constructional diagram and characteristic curves, explain the working of IGBT. What are its merits compared to conventional transistors ?

(5 × 12 = 60 marks)